US009073361B2

(12) **United States Patent**
Murata et al.

(10) **Patent No.: US 9,073,361 B2**
(45) **Date of Patent: Jul. 7, 2015**

(54) **LIQUID EJECTION APPARATUS**

(71) Applicants: **Satoshi Murata**, Nagoya (JP); **Shigeki Kato**, Toyoake (JP)

(72) Inventors: **Satoshi Murata**, Nagoya (JP); **Shigeki Kato**, Toyoake (JP)

(73) Assignee: **BROTHER KOGYO KABUSHIKI KAISHA**, Nagoya-Shi, Aichi-Ken (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **14/230,745**

(22) Filed: **Mar. 31, 2014**

(65) **Prior Publication Data**

US 2014/0354728 A1 Dec. 4, 2014

(30) **Foreign Application Priority Data**

May 31, 2013 (JP) 2013-115712

(51) **Int. Cl.**

B41J 29/38 (2006.01)
B41J 2/01 (2006.01)
B41J 11/00 (2006.01)
B41J 3/60 (2006.01)

(52) **U.S. Cl.**

CPC . ***B41J 11/002*** (2013.01); ***B41J 3/60*** (2013.01)

(58) **Field of Classification Search**

CPC B41J 3/60; B41J 11/002; B41J 11/007
USPC 347/16, 101, 102, 104
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2012/0050376	A1 *	3/2012	Nagoshi et al.	347/19
2013/0135409	A1 *	5/2013	Ito et al.	347/104

FOREIGN PATENT DOCUMENTS

JP	2001-063019	A	3/2001
JP	2008-080808	A	4/2008
JP	2009-083355	A	4/2009
JP	2010-000711	A	1/2010

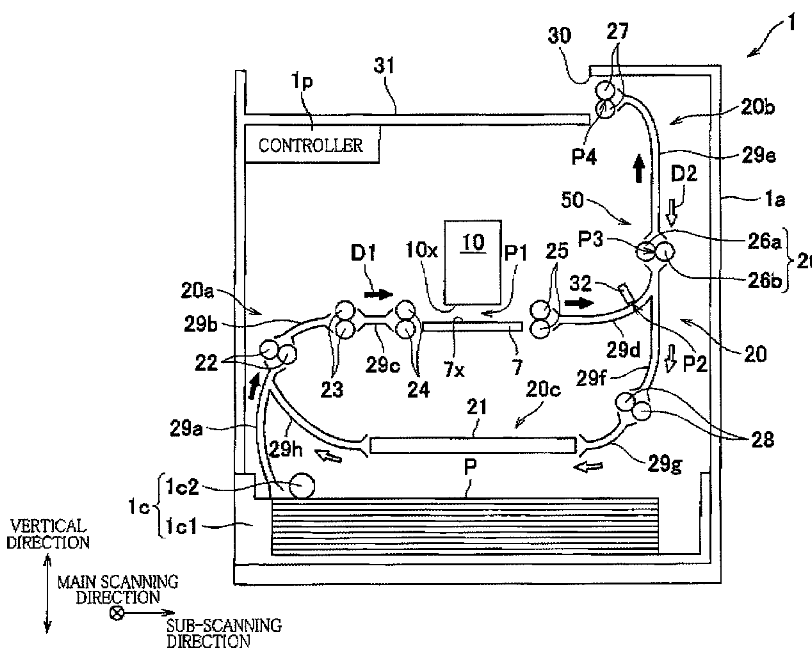
* cited by examiner

Primary Examiner — Jannelle M Lebron
(74) *Attorney, Agent, or Firm* — Merchant & Gould PC

(57) **ABSTRACT**

A liquid ejection apparatus includes: a liquid ejection head; a first conveyor for conveying a recording medium in a first direction to a recording position; a second conveyor disposed downstream of the recording position; a third conveyor for returning the recording medium to the first conveyor; and a dryer disposed at a drying position located downstream of the recording position in the first direction. A controller controls: image recording on a first surface of the recording medium opposite its second surface (first processing); the second conveyor to convey the recorded recording medium in the first direction until its upstream edge portion reaches a downstream side of the drying position in the first direction (second processing); the second conveyor to convey the recording medium in a second direction (third processing); and image recording on the second surface (fourth processing). The dryer dries the recording medium in the second processing.

16 Claims, 10 Drawing Sheets



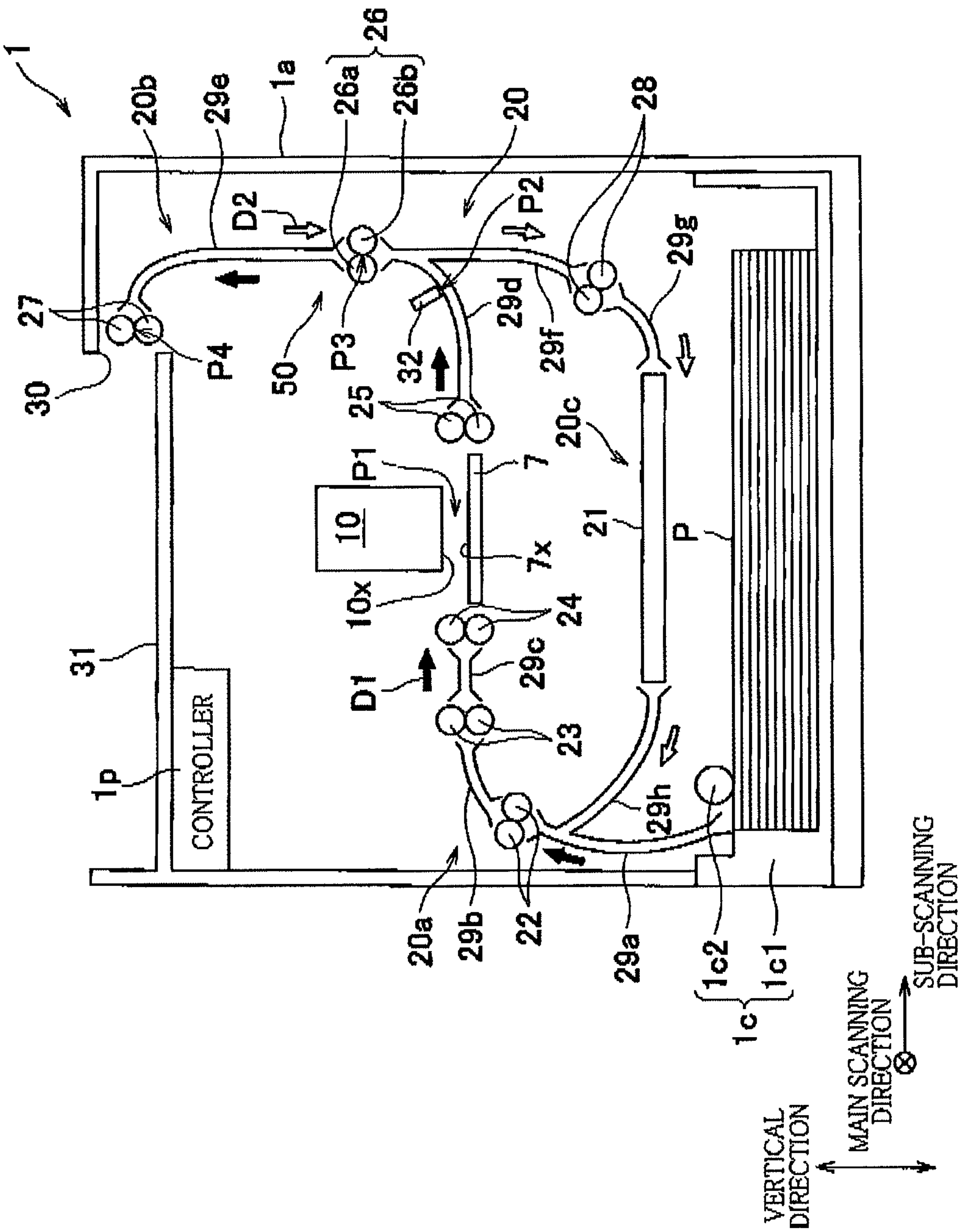

CONTROLLER
VERTICAL DIRECTION
MAIN SCANNING DIRECTION
SUB-SCANNING DIRECTION

FIG. 1

FIG.2

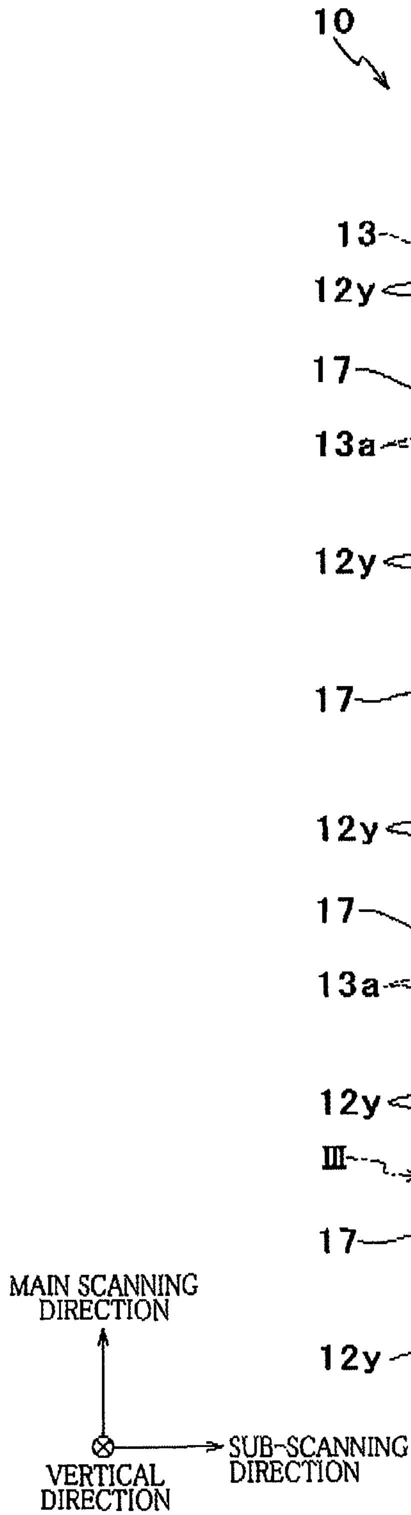

10
12
12x
12y
13
12y
17
17
13a
12y
12y
17
17
12y
12y
17
17
13a
12y
12y
17
III
17
12y
13
12y
MAIN SCANNING DIRECTION
SUB-SCANNING DIRECTION
VERTICAL DIRECTION

FIG.3

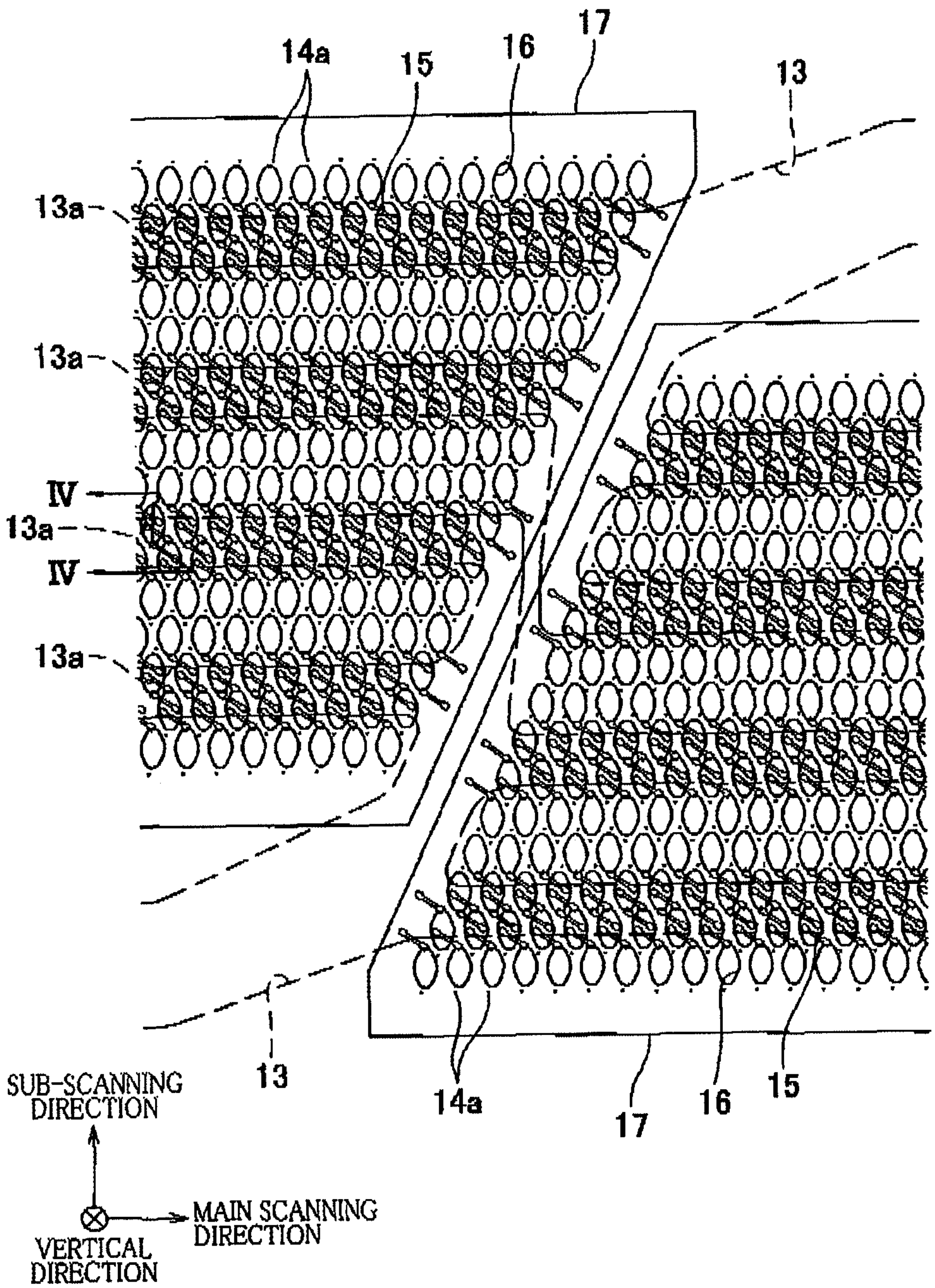

17
14a
15
16
13
13a
13a
IV
13a
IV
13a
13
14a
17
16
15
SUB-SCANNING DIRECTION
MAIN SCANNING DIRECTION
VERTICAL DIRECTION

FIG.4

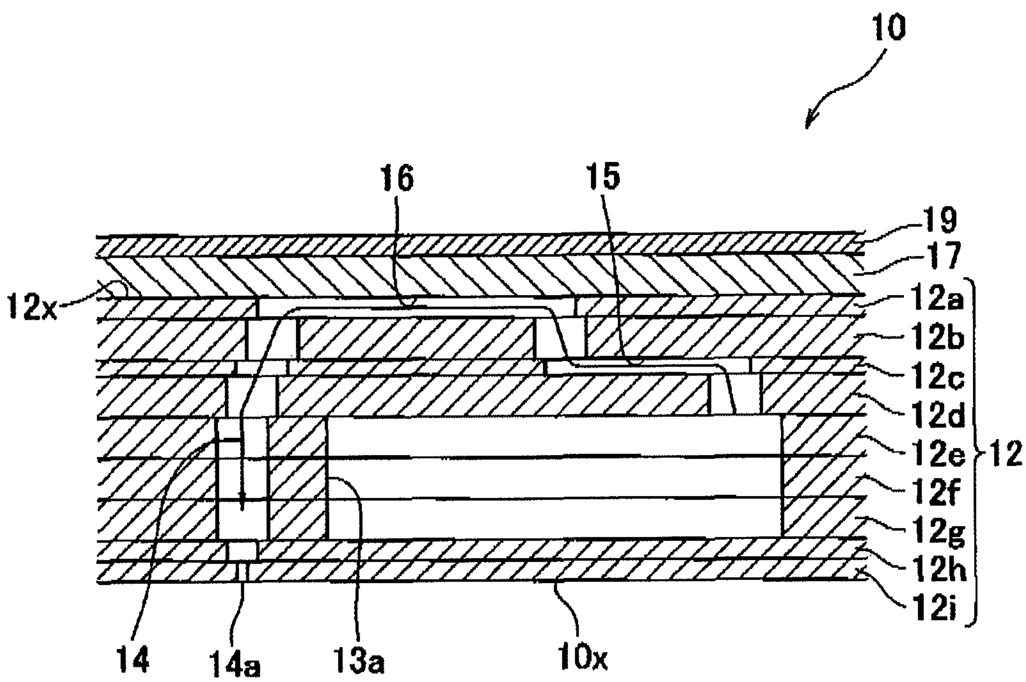

10
16
15
19
17
12x
12a
12b
12c
12d
12e
12
12f
12g
12h
12i
14
14a
13a
10x

FIG.5

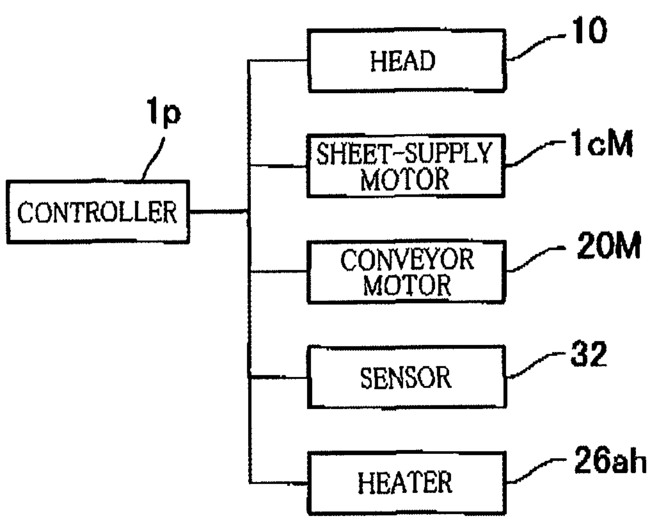

HEAD
10
1p
SHEET-SUPPLY MOTOR
1cM
CONTROLLER
CONVEYOR MOTOR
20M
SENSOR
32
HEATER
26ah

FIG.6

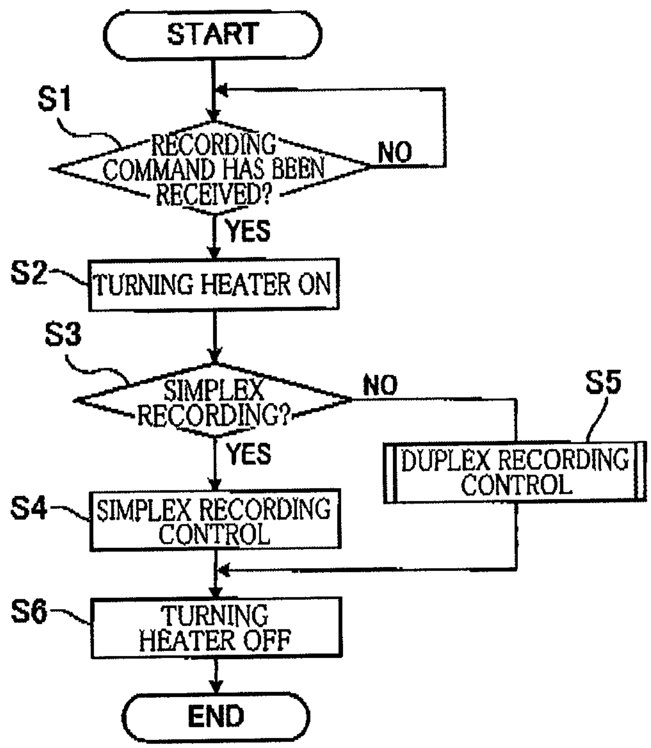

START
S1
RECORDING COMMAND HAS BEEN RECEIVED?
NO
YES
S2
TURNING HEATER ON
S3
SIMPLEX RECORDING?
NO
S5
YES
DUPLEX RECORDING CONTROL
S4
SIMPLEX RECORDING CONTROL
S6
TURNING HEATER OFF
END

FIG.7

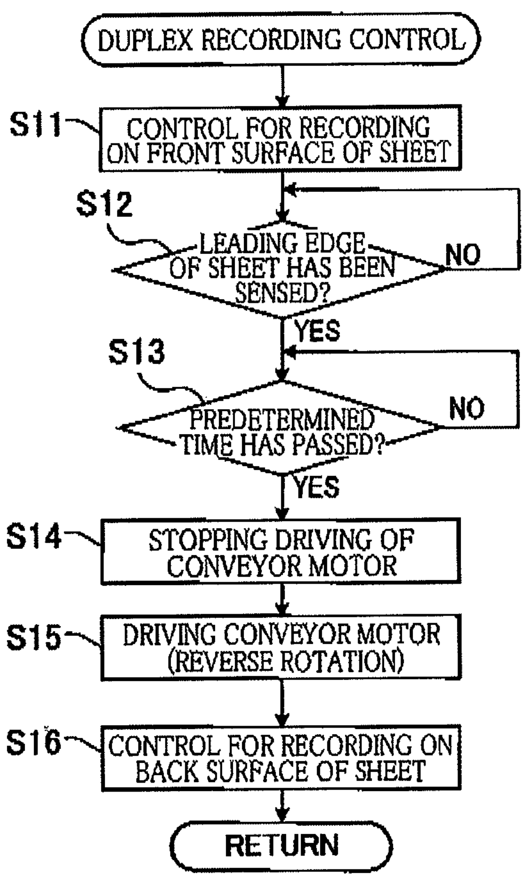
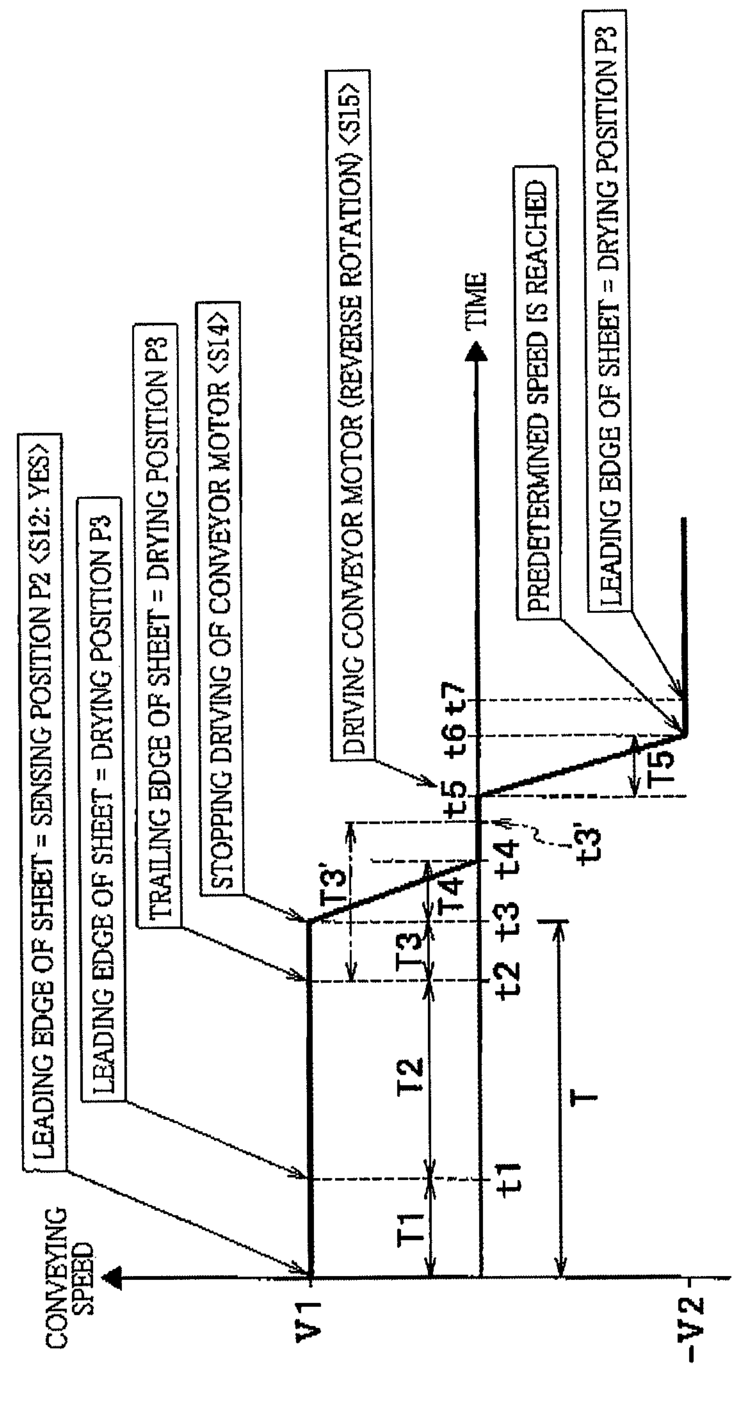

DUPLEX RECORDING CONTROL
S11
CONTROL FOR RECORDING ON FRONT SURFACE OF SHEET
S12
LEADING EDGE OF SHEET HAS BEEN SENSED?
NO
YES
S13
PREDETERMINED TIME HAS PASSED?
NO
YES
S14
STOPPING DRIVING OF CONVEYOR MOTOR
S15
DRIVING CONVEYOR MOTOR (REVERSE ROTATION)
S16
CONTROL FOR RECORDING ON BACK SURFACE OF SHEET
RETURN

FIG.8



CONVEYING SPEED
V1
-V2
TIME
LEADING EDGE OF SHEET = SENSING POSITION P2 <S12: YES>
LEADING EDGE OF SHEET = DRYING POSITION P3
TRAILING EDGE OF SHEET = DRYING POSITION P3
STOPPING DRIVING OF CONVEYOR MOTOR <S14>
DRIVING CONVEYOR MOTOR (REVERSE ROTATION) <S15>
PREDETERMINED SPEED IS REACHED
LEADING EDGE OF SHEET = DRYING POSITION P3
T1
T2
T3
T3'
T4
T5
T
t1
t2
t3
t4
t3'
t5
t6
t7

FIG.9

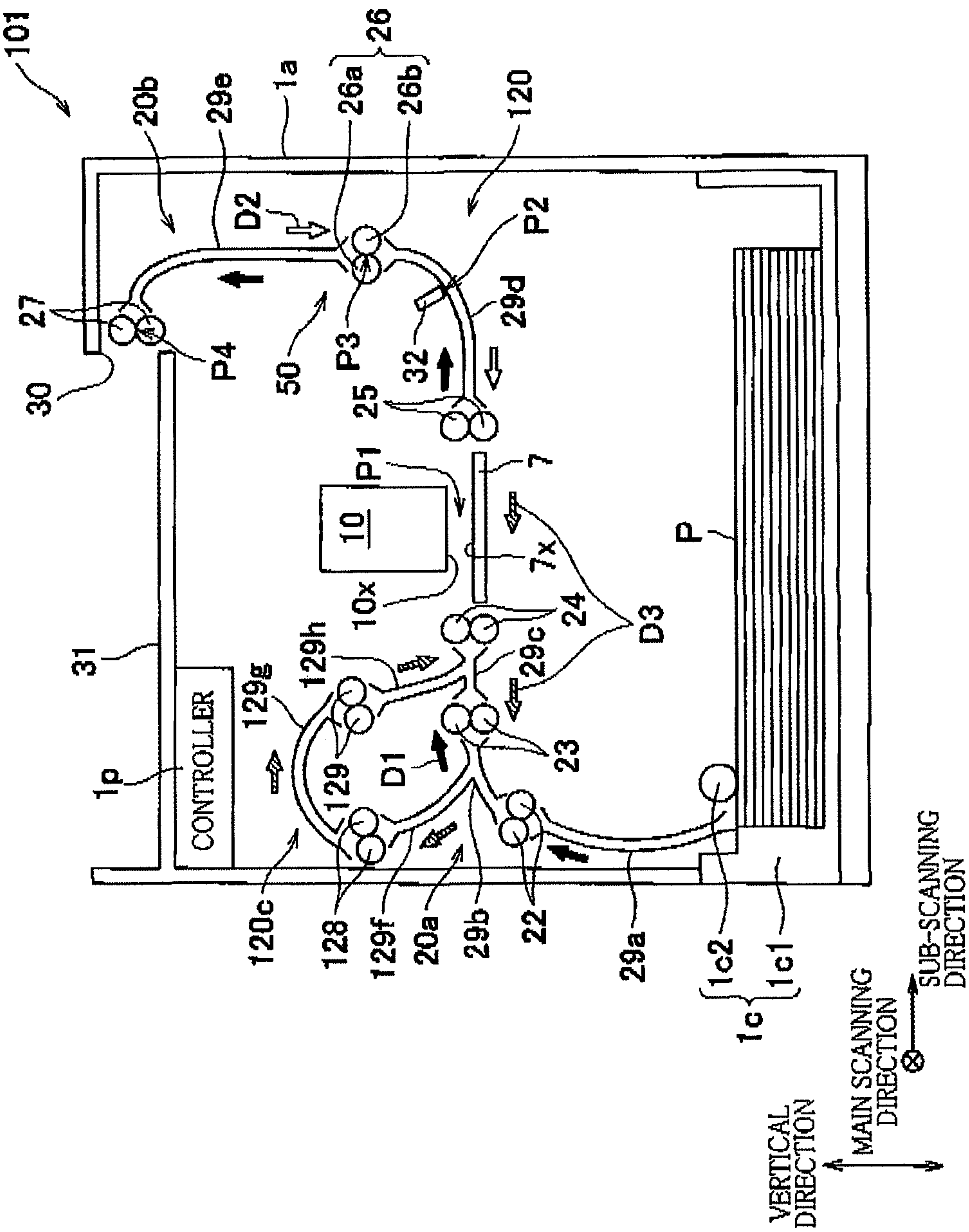
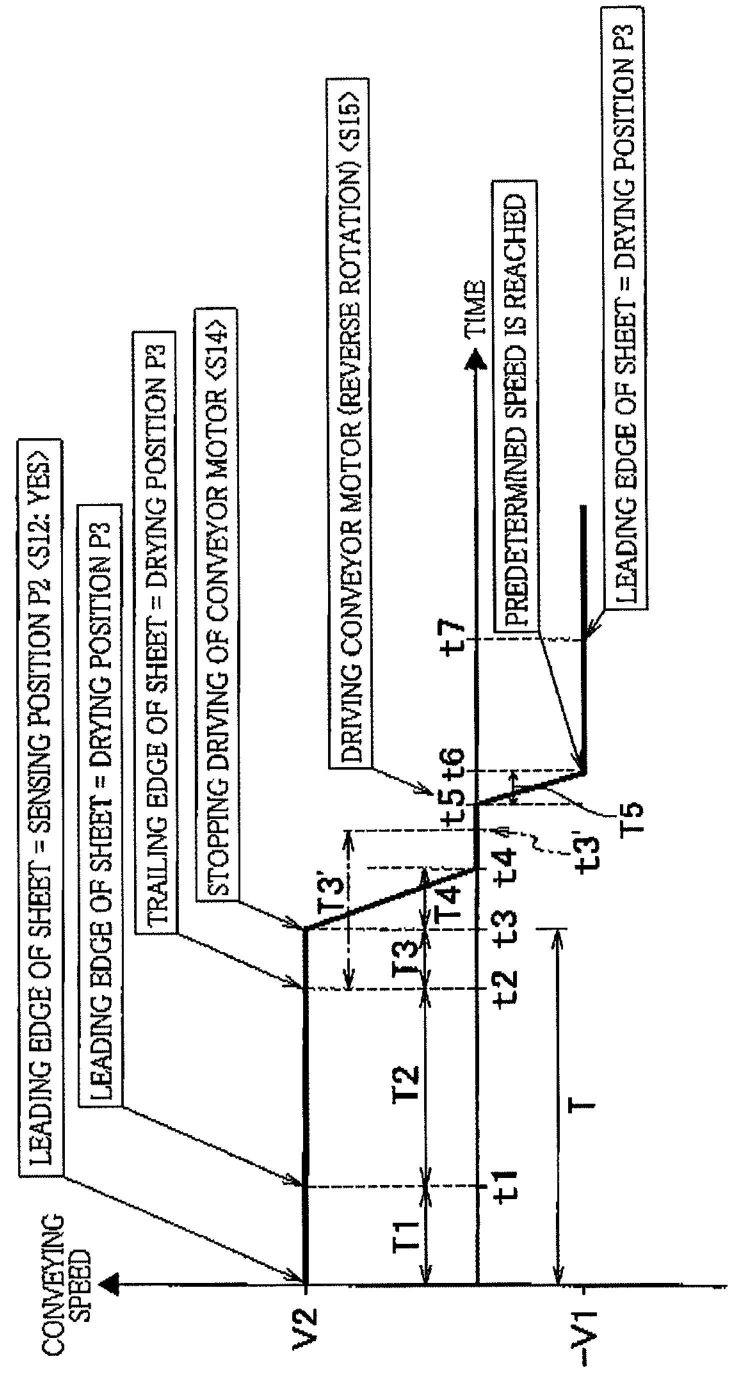
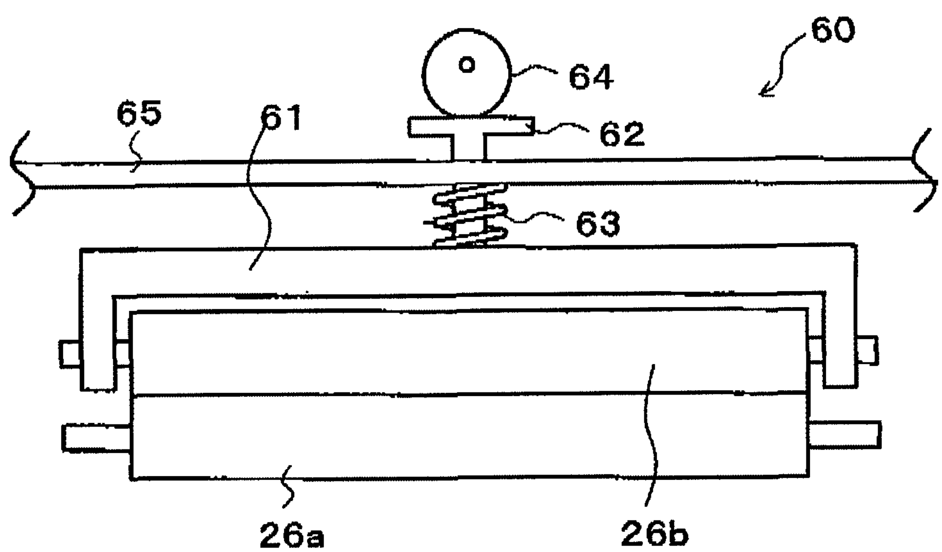

101
CONTROLLER
VERTICAL DIRECTION
MAIN SCANNING DIRECTION
SUB-SCANNING DIRECTION
1a
1p
1c
1c1
1c2
7
7x
10
10x
20a
20b
22
23
24
25
26
26a
26b
27
29a
29b
29c
29d
29e
30
31
32
50
120
120c
128
129
129f
129g
129h
D1
D2
D3
P
P1
P2
P3
P4

FIG.10



CONVEYING SPEED
TIME
V2
−V1
LEADING EDGE OF SHEET = SENSING POSITION P2 <S12: YES>
LEADING EDGE OF SHEET = DRYING POSITION P3
TRAILING EDGE OF SHEET = DRYING POSITION P3
STOPPING DRIVING OF CONVEYOR MOTOR <S14>
DRIVING CONVEYOR MOTOR (REVERSE ROTATION) <S15>
PREDETERMINED SPEED IS REACHED
LEADING EDGE OF SHEET = DRYING POSITION P3
T1
T2
T3
T3'
T4
T5
T
t1
t2
t3
t3'
t4
t5
t6
t7

FIG.11



LIQUID EJECTION APPARATUS

CROSS REFERENCE TO RELATED APPLICATION

The present application claims priority from Japanese Patent Application No. 2013-115712, which was filed on May 31, 2013, the disclosure of which is herein incorporated by reference in its entirety.

BACKGROUND

1. Technical Field

The present invention relates to a liquid ejection apparatus configured to eject liquid such as ink.

2. Description of the Related Art

There is known a liquid ejection apparatus configured to record images respectively on opposite surfaces (first and second surfaces) of a recording medium. There is also known another liquid ejection apparatus configured to dry a recording medium after image recording to prevent smear of liquid on a recording medium. For example, a liquid ejection apparatus of this kind uses an output roller having a heater therein to convey a sheet and dry the sheet for which an image is recorded on its first surface. After rotation of the output roller is temporarily stopped in a state in which a trailing edge of the sheet is nipped by the output roller, the output roller is rotated in a reverse direction to supply the sheet again for image recording on the second surface of the sheet.

In this liquid ejection apparatus, after the rotation of the output roller is temporarily stopped in the state in which the trailing edge of the sheet is nipped by the output roller, the heater is turned off, and the output roller is rotated in the reverse direction. Alternatively, after the rotation of the output roller is temporarily stopped in the state in which the trailing edge of the sheet is nipped by the output roller, the output roller is rotated in the reverse direction to supply the sheet again for image recording on the second surface of the sheet, and the heater is turned off after the image recording on the second surface.

SUMMARY

However, some length of time is required for the output roller to return to a normal temperature from turning-off of the heater. Accordingly, in the above-described configuration in which the output roller is rotated in the reverse direction in the state in which the trailing edge of the sheet is nipped by the output roller, a large amount of heat is applied to the trailing edge of the sheet regardless of the timing of turning off the heater when compared with other areas on the sheet. This results in unevenness in a degree of dryness of a recording medium, i.e., the sheet, leading to curl and discoloration of the recording medium.

This invention has been developed to provide a liquid ejection apparatus capable of reducing unevenness in a degree of dryness of a recording medium.

The present invention provides a liquid ejection apparatus, including: a liquid ejection head formed with a plurality of ejection openings and configured to eject liquid from the plurality of ejection openings; a first conveyor configured to convey a recording medium in a first direction to a recording position which opposes the plurality of ejection openings; a second conveyor disposed downstream of the recording position in the first direction, the second conveyor being configured to convey the recording medium conveyed by the first conveyor, in the first direction and a second direction that is

reverse to the first direction; a third conveyor configured to convey the recording medium conveyed in the second direction by the second conveyor, to an upstream side of the recording position in the first direction to enter the recording medium into a conveyance path of the first conveyor; a dryer configured to dry the recording medium conveyed by the second conveyor, at a drying position located downstream of the recording position in the first direction; and a controller configured to control the liquid ejection head, the first conveyor, the second conveyor, the third conveyor, and the dryer. The controller is configured to execute: a first processing in which the controller controls the liquid ejection head and the first conveyor to record an image on a first surface of the recording medium which opposes a second surface thereof; a second processing in which after the first processing the controller controls the second conveyor to convey the recording medium for which the image is recorded on the first surface thereof; in the first direction until an upstream edge portion of the recording medium in the first direction reaches a position located downstream of the drying position in the first direction; a third processing in which after the second processing the controller controls the second conveyor to convey the recording medium for which the image is recorded on the first surface thereof, in the second direction; and a fourth processing in which after the third processing the controller controls the third conveyor, the first conveyor, and the liquid ejection head to record an image on the second surface of the recording medium. The controller is configured to control the dryer to dry the recording medium at least in the second processing.

The present invention provides a liquid ejection apparatus, including: a liquid ejection head formed with a plurality of ejection openings and configured to eject liquid from the plurality of ejection openings; a first conveyor configured to convey a recording medium in a first direction to a recording position which opposes the plurality of ejection openings; a second conveyor disposed downstream of the recording position in the first direction, the second conveyor being configured to convey the recording medium conveyed by the first conveyor, in the first direction and a second direction that is reverse to the first direction; a third conveyor configured to convey the recording medium conveyed in the second direction by the second conveyor, to an upstream side of the recording position in the first direction to enter the recording medium into a conveyance path of the first conveyor; and a dryer configured to dry the recording medium conveyed by the second conveyor, at a drying position located downstream of the recording position in the first direction. The dryer includes: a first forward/reverse rotatable roller pair at least partly constituting the second conveyor and rotatable forwardly and reversely; and a heater configured to heat at least one of two rollers constituting the first forward/reverse rotatable roller pair. The second conveyor includes a second forward/reverse rotatable roller pair rotatable forwardly and reversely and disposed downstream of the drying position in the first direction.

BRIEF DESCRIPTION OF THE DRAWINGS

The objects, features, advantages, and technical and industrial significance of the present invention will be better understood by reading the following detailed description of the embodiments of the invention, when considered in connection with the accompanying drawings, in which:

FIG. **1** is a schematic side view illustrating an internal structure of an ink-jet printer according to a first embodiment of the present invention;

FIG. **2** is a plan view illustrating an ink-jet head of the printer in FIG. **1**;

FIG. **3** is an enlarged view illustrating area III enclosed by one-dot chain line in FIG. **2**;

FIG. **4** is a cross-sectional view taken along line IV-IV in FIG. **3**;

FIG. **5** is a block diagram illustrating an electric configuration of the printer in FIG. **1**;

FIG. **6** is a flow chart illustrating control executed by a controller of the printer;

FIG. **7** is a flow chart illustrating duplex recording control in FIG. **6**;

FIG. **8** is a graph illustrating changes in sheet conveying speed in the process of switching a sheet conveying direction from a first direction to a second direction in duplex recording;

FIG. **9** is a schematic side view illustrating an internal structure of an inkjet printer according to a second embodiment of the present invention;

FIG. **10** is a graph illustrating changes in sheet conveying speed in the process of switching the sheet conveying direction from the first direction to the second direction in duplex recording in an ink-jet printer according to a third embodiment of the present invention; and

FIG. **11** is a schematic side view of a nip-pressure changing mechanism of a dryer included in an ink-jet printer according to an alternative embodiment of the present invention.

DETAILED DESCRIPTION OF THE EMBODIMENTS

Hereinafter, there will be described embodiments of the present invention by reference to the drawings.

First, there will be explained, with reference to FIG. **1**, an overall configuration of an ink-jet printer **1** according to a first embodiment of the present invention.

The printer **1** includes a housing **1***a* having a rectangular parallelepiped shape. A sheet-output portion **31** is provided on a top plate of the housing **1***a*. The housing **1***a* accommodates an ink-jet head **10**, a platen **7**, a conveyor unit **20**, a dryer **50**, a sensor **32**, a sheet-supply unit **1***c*, a controller **1***p*, and so on. Formed in the housing **1***a* is a sheet conveyance path through which a sheet P is conveyed from the sheet-supply unit **1***c* to the sheet-output portion **31** along bold arrows illustrated in FIG. **1**. A cartridge, not shown, storing black ink to be supplied to the head **10** is removably provided in the housing **1***a*. The cartridge is connected to the head **10** by a tube and other connecting members to supply the ink to the head **10**.

The head **10** is a line head having a generally rectangular parallelepiped shape elongated in a main scanning direction or a direction perpendicular to a sheet surface of FIG. **1**. A lower surface of the head **10** is an ejection surface **10***a* having a multiplicity of ejection openings **14***a* (see FIGS. **3** and **4**) opened therein.

The platen **7** is a flat plate disposed opposing the ejection surface **10***x*. A space appropriate for recording is formed between an upper surface **7***x* of the platen **7** and the ejection surface **10***x*.

The conveyor unit **20** includes a first conveyor **20***a*, a second conveyor **20***b*, and a third conveyor **20***c*. The first conveyor **20***a* conveys the sheet P supplied from the sheet-supply unit **1***c*, to a recording position P1 in a first direction D1 which is a direction indicated by the bold arrows in FIG. **1**. The first conveyor **20***a* includes roller pairs **22**-**24** and guides **29***a*-**29***c*. The recording position P1 is located on the upper surface **7***x* of the platen **7** and opposes the ejection openings **14***a*. The second conveyor **20***b* is disposed downstream of the recording position P1 in the first direction D1 and designed to convey the sheet P conveyed by the first conveyor **20***a*, in the first direction D1 and a second direction D2 different from or reverse to the first direction D1 which is indicated by white arrows in FIG. **1**. The second conveyor **20***b* includes roller pairs **25**-**27** and guides **29***d*, **29***e*. Two roller pairs **26**, **27** of the three roller pairs **25**-**27** are forward/reverse rotatable roller pairs each rotatable in forward and reverse directions. The roller pair **27** is one example of a first forward/reverse rotatable roller pair, and the roller pair **26** is one example of a second forward/reverse rotatable roller pair. The third conveyor **20***c* conveys the sheet P conveyed by the second conveyor **20***b* in the second direction D2, to a position located upstream of the recording position P1 in the first direction D1 (i.e., a position near the roller pair **22** on an upstream side thereof) so as to return the sheet P into a sheet conveyance path of the first conveyor **20***a*. The third conveyor **20***c* includes a cassette **21**, a roller pair **28**, and guides **29***f*-**29***h*.

The roller pairs **22**-**28** are arranged in the sheet conveyance path so as to be spaced apart from each other appropriately. One roller of each of the roller pairs **22**-**28** is a drive roller which is rotated by a conveyor motor **20**M (see FIG. **5**) under control of the controller **1***p*. The other roller of each of the roller pairs **22**-**28** is a driven roller which is rotated by the rotation of the one roller. In each of the roller pairs **22**-**28**, the one roller and the other roller nipping the sheet P therebetween are rotated such that the rotational direction of the one roller and the rotational direction of the other roller are reverse to each other. All the roller pairs **22**-**28** are driven by the conveyor motor **20**M so as to be rotated at the same speed. Each of the guides **29***a*-**29***h* is constituted by a pair of plates which are spaced apart from each other in a planar direction. The cassette **21** is disposed over a sheet-supply tray **1***c***1** and under the platen **7** so as to define a space through which the sheet P can be conveyed.

The dryer **50** is designed to dry the sheet P conveyed by the second conveyor **20***b*, at a drying position P3 located downstream of the recording position P1 in the first direction D1. The dryer **50** includes a roller pair **26** and a heater **26***ah* (see FIG. **5**). The heater **26***ah* heats one of two rollers **26***a*, **26***b* constituting the roller pair **26**, in the present embodiment, the heater **26***ah* heats the roller **26***a*. Under the control of the controller **1***p*, when the heater **26***ah* is turned on, the heater **26***ah* heats the roller **26***a* to apply heat to a portion of the sheet P which is nipped by the roller pair **26**, thereby drying the portion of the sheet P. In other words, the roller **26***a* is a contact member which contacts one of opposite surfaces of the sheet P to apply heat to the sheet P. The drying position P3 is a position at which the roller pair **26** nips the sheet P.

The sensor **32** outputs a signal based on the presence or absence of the sheet P and is disposed upstream of the drying position P3 in the first direction D1. The sensor **32** senses the presence or absence of the sheet P at a sensing position P2 located on the sheet conveyance path.

The sheet-supply unit **1***c* includes the sheet-supply tray **1***c***1** and a sheet-supply roller **1***c***2**. The sheet-supply tray **1***c***1** is removable from the housing **1***a*. The sheet-supply tray **1***c***1** is a container opening upward and capable of containing a plurality of sheets P. The controller **1***p* drives a sheet-supply motor **1***c*M (see FIG. **5**) to rotate the sheet-supply roller **1***c***2**, supplying an uppermost one of the sheets P accommodated in the sheet-supply tray **1***c***1**.

The controller **1***p* includes a central processing unit (CPU) as a computing device, a read only memory (ROM), a random access memory (RAM) including a non-transitory RAM, an application specific integrated circuit (ASIC), an interface

(I/F), an input/output port (I/O), and a timer. The ROM stores programs to be executed by the CPU, various kinds of fixed data, and other similar data. The RAM temporarily stores data such as image data necessary for execution of the programs. The ASIC executes rewriting and sorting of image data and other processings such as a signal processing and an image processing. The interface transmits and receives data to and from an external device such as a PC connected to the printer **1**. The input/output port inputs and outputs signals transmitted from various sensors. It is noted that the controller **1***p* may not include the ASIC, and the programs and so on executed by the CPU may execute rewriting and sorting of image data and other processings.

The controller **1***p* controls the head **10** and the conveyor unit **20** to record an image on the sheet P based on a recording command supplied from the external device. That is, the controller **1***p* controls a sheet conveying operation in which the conveyor unit **20** conveys the sheet P, and an ink ejecting operation in which the head **10** ejects the ink onto the sheet P being conveyed.

The sheet P supplied by the sheet-supply unit **1***c* is conveyed in the first direction D1 by the first conveyor **20***a* being controlled by the controller **1***p*. When the sheet P passes through the recording position PI, the controller **1***p* controls the head **10** to eject the ink from the ejection openings **14***a* (see FIG. **4**) onto a surface of the sheet P or a first surface (i.e., a surface of the sheet P which faces downward in the sheet-supply tray **1***c***1**) to record an image on the surface of the sheet P. In the case of simplex recording in which an image is formed only one of opposite surfaces of the sheet P, the sheet P is thereafter discharged onto the sheet-output portion **31** from an opening **30** formed in an upper portion of the housing **1***a*. In the ease of duplex recording in which images are recorded respectively on a front surface and a back surface or a second surface of the sheet P, the controller **1***p* reverses rotational directions of the roller pairs **26**, **27** when the sheet P is nipped by the roller pair **27**. As a result, the sheet P is conveyed by the second conveyor **20***b* in the second direction D2 so as to be conveyed to the third conveyor **20***c*. The third conveyor **20***c* conveys the sheet P into the conveyance path of the first conveyor **20***a* at the position located upstream of the recording position PI in the first direction D1 (i.e., the position near the roller pair **22** on an upstream side thereof). The sheet P is conveyed by the first conveyor **20***a* again in the first direction D1 to the recording position P1 where an image is recorded on the back surface of the sheet P, and thereafter the sheet P is discharged from the opening **30** onto the sheet-output portion **31**. A command for the simplex recording or the duplex recording is contained in the recording command.

There will be next explained the construction of the head **10** with reference to FIGS. **2**-**4**. It is noted that, in FIG. **3**, pressure chambers **16** and apertures **15** are illustrated by solid lines for easier understanding purposes though these elements are located under actuator units **17** and thus should be illustrated by broken lines.

The head **10** includes a passage unit **12**, a reservoir unit, the eight actuator units **17**, eight flexible printed circuits (FPCs) **19**, and a circuit board.

The passage unit **12** is a stacked body constituted by nine metal plates **12***a*-**12***i* having generally the same size, and passages are formed in the passage unit **12**. These passages include manifold passages **13**, sub-manifold passages **13***a*, and individual passages **14**. An upper surface **12***x* of the passage unit **12** has openings **12***y*. Each of the manifold passages **13** has a corresponding one of the openings **12***y* at its one end. Each of the sub-manifold passages **13***a* is branched off from a corresponding one of the manifold passages **13**. The individual passages **14** are provided respectively for the ejection openings **14***a* and respectively extend from outlets of the sub-manifold passages **13***a* to the ejection openings **14***a* via the pressure chambers **16** and the apertures **15** each as a restrictor for adjusting a passage resistance. A lower surface of the passage unit **12** which opposes the upper surface **12***x* is the ejection surface **10***x*.

The pressure chambers **16** are formed for and connected to the respective ejection openings **14***a*. An opening of each pressure chamber **16** has a generally rhombic shape and is formed in a predetermined area on a corresponding one of the actuator units **17** provided on the upper surface **12***x* such that the pressure chambers **16** are arranged in matrix (see FIG. **3**). In areas on a lower surface (i.e., the ejection surface **10***x*) of the head **10** which oppose the predetermined areas of the respective actuator units **17**, the ejection openings **14***a* are arranged in matrix in the same configuration as that of the pressure chambers **16**.

The reservoir unit has a passage including a reservoir. The reservoir temporarily stores the ink supplied from the cartridge. This passage is coupled at its one end to a cartridge by a tube, for example, and at the other end to the passages of the passage unit **12**. Protruding portions and recessed portions are formed on and in a lower surface of the reservoir unit. Distal end faces of the respective protruding portions are fixed to the upper surface **12***x* at areas not overlapping the actuator units **17** (i.e., areas including the openings **12***y* which are enclosed by two-dot chain lines in FIG. **2**). Passages connected to the reservoir are open in the distal end faces of the respective protruding portions. The recessed portions oppose to the upper face **12***x*, faces of the actuator units **17**, and faces of the FPCs **19** with a small space therebetween.

As illustrated in FIG. **2**, the eight actuator units **17** are fixed to the upper surface **12***x* so as to be arranged in two arrays in a staggered configuration in the main scanning direction. Each of the actuator units **17** has a trapezoid shape as its outer shape and covers the openings of the corresponding pressure chambers **16** formed in the predetermined area of the respective actuator unit **17**. Each actuator unit **17** is constituted by piezoelectric layers, a common electrode, and individual electrodes. Each of the piezoelectric layers and the common electrode has a trapezoid shape which defines the outer shape of the actuator unit **17**. The individual electrodes are provided for the respective pressure chambers **16** and arranged on an upper surface of the piezoelectric layer at areas respectively opposing the pressure chambers **16** in the vertical direction. A portion of the actuator units **17** which is sandwiched between each of the individual electrodes and a corresponding one of the pressure chambers **16** functions as an individual piezoelectric actuator for the pressure chamber **16**. The actuators are deformable independently of each other. When a drive voltage is applied to each of the actuators via a corresponding one of the FPCs **19**, the actuator makes unimorph deformation to change a volume of the corresponding pressure chamber **16**. This change in volume applies energy to the ink in the pressure chamber **16**, causing the ink to be ejected from a corresponding one of the ejection opening **14***a*.

The eight FPCs **19** are connected respectively to the eight actuator units **17**. Each of the FPCs **19** is fixed at its one end to a corresponding one of the actuator units **17** and fixed at the other end to the circuit board. Each FPC **19** includes wirings and terminals corresponding to the electrodes of the corresponding actuator unit **17**, and a driver IC is mounted on the FPC **19** between the actuator unit **17** and the circuit board. The wirings are connected to an output terminal of the driver IC. The circuit board adjusts a signal input from the controller **1***p* and outputs the adjusted signal to the driver IC through the wiring of the FPC **19**. The driver IC converts this signal to a drive signal and transmits this drive signal to the electrodes of the actuator units **17** through the wirings of the FPC **19**.

There will be next explained control of the controller **1***p* with reference to FIGS. **6** and **7**.

The routine illustrated in FIG. **6** begins with S**1** at which the controller **1***p* determines whether a recording command has been received from the external device or not. When the recording command has not been received (S**1**: NO), the controller **1***p* repeats the processing at S**1**. When the recording command is received (S**1**: YES), the controller **1***p* at S**2** turns on the heater **26***ah*. The controller **1***p* at S**3** refers to the recording command to determine whether the recording command indicates the simplex recording or not.

In the case of the simplex recording (**53**: YES), the controller **1***p* at S**4** executes control for the simplex recording. Specifically, the controller **1***p* controls the sheet-supply motor **1***c*M, the conveyor motor **20**M, and the head **10** such that the uppermost sheet P in the sheet-supply tray **1***c***1** is supplied by the sheet-supply unit **1***c* and conveyed in the first direction D1 to the recording position P1 where an image is recorded on a surface of the sheet P, and thereafter the sheet P is discharged from the opening **30** onto the sheet-output portion **31**.

In the case of the duplex recording (S**3**: NO), the controller **1***p* at S**5** executes control for the duplex recording. In this duplex recording control, as illustrated in FIG. **7**, the controller **1***p* initially at S**11** executes control for recording on a front surface of the sheet P. Specifically, the controller **1***p* controls the sheet-supply motor **1***c*M, the conveyor motor **20**M, and the head **10** such that the uppermost sheet P in the sheet-supply tray **1***c***1** is supplied by the sheet-supply unit **1***c* and conveyed in the first direction D1 to the recording position P1 where an image is recorded on the front surface of the sheet P.

The controller **1***p* at S**12** determines based on signals output from the sensor **32** whether a downstream edge portion of the sheet P in the first direction D1 (i.e., a leading edge of the sheet P in the first direction D1) has reached the sensing portion P2 or not. The controller **1***p* determines that the leading edge of the sheet P has reached the sensing position P2, at the timing when the signal output from the sensor **32** is changed from a signal indicative of the absence of the sheet P to a signal indicative of the presence of the sheet P. When the leading edge of the sheet P has not reached the sensing position P2 (S**12**: NO), the controller **1***p* repeats the processing at S**12**.

When the leading edge of the sheet P has reached the sensing position P2 (S**12**: YES), the controller **1***p* at S**13** refers to a timer to determine whether or not a predetermined length of time T has passed from the sense of the sensor **32**, i.e., the timing when the leading edge of the sheet P had reached the sensing position P2. The predetermined length of time T may be determined in any method based on a design value and/or an actual measurement value. One example of the calculation of the predetermined length of time T will be explained later.

When the predetermined length of time T has passed from the timing when the leading edge of the sheet P had reached the sensing position P2 (S**13**: YES), the controller **1***p* at S**14** outputs a command for stopping the driving of the conveyor motor **20**M. After the driving of the conveyor motor **20**M is completely stopped, and thereby the rotations of the roller pairs **26**, **27** are completely stopped, the controller **1***p* at S**15** outputs a command for rotating the conveyor motor **20**M in the reverse direction. As a result, the roller pairs **26**, **27** are rotated in the reverse direction to convey the sheet P in the second direction D2.

After S**15**, the controller **1***p* at S**16** executes control for image recording on a back surface of the sheet P. Specifically, the controller **1***p* controls the conveyor motor **20**M and the head **10** such that the sheet P conveyed by the second conveyor **20***b* in the second direction D2 is conveyed by the third conveyor **20***c* so as to enter into the conveyance path of the first conveyor **20***a* and is then conveyed by the first conveyor **20***a* again in the first direction D1 to the recording position P1 where an image is recorded on the back surface of the sheet P, and thereafter the sheet P is discharged from the opening **30** onto the sheet-output portion **31**.

After S**16**, the controller **1***p* finishes this routine and executes the processing at S**6** in FIG. **6**. After S**4** and S**5**, the controller **1***p* at S**6** tarns off the heater **26***ah*, and this routine ends.

During the processings at S**2**-S**6**, the controller **1***p* executes ON-OFF control for the heater **26***ah* to keep the temperature of the roller **26***a* within a predetermined range that is appropriate for drying the sheet P. Specifically, each time when a predetermined length of time A has passed, the controller **1***p* determines whether or not the temperature of the roller **26***a* is equal to or higher than a predetermined temperature B, based on a signal output from a sensor for sensing the temperature of the roller **26***a*. When the temperature of the roller **26***a* is lower than the predetermined temperature B, the controller **1***p* turns on the heater **26***ah*. When the temperature of the roller **26***a* is equal to or higher than the predetermined temperature B, the controller **1***p* turns off the heater **26***ah*.

It is noted that the control for the temperature of the roller **26***a* is not limited to the ON-OFF control described above. Other examples of the control for the temperature of the roller **26***a* include: control using proportional, integral, or derivative values; and proportional-integral-derivative control (PID control) using proportional, integral, and derivative values in combination. Also, the predetermined temperature B may be set at any suitable value. The predetermined temperature B is preferably set at a temperature that is appropriate for drying the sheet P in a second processing of the simplex recording (i.e., a period before the sheet P is discharged to an outside of the housing **1***a*) and appropriate for drying the sheet P in a period before the image recording is performed on the back surface of the sheet P in the duplex recording (i.e., before a fourth processing). The predetermined temperature B may be the same temperature or different temperatures in the simplex recording and the duplex recording. Also, the predetermined temperature B may be determined according to a type of a recording medium, an image to be recorded on the sheet P, and so on.

Since the temperature of the roller **26***a* is thus kept within the predetermined range, the sheet P is dried at the drying position P3 by heat applied to the portion of the sheet P which is nipped by the roller pair **26** in any of the simplex recording control (S**4**) and the duplex recording control (S**5**).

The predetermined length of time A, the predetermined temperature B, and the predetermined length of time T are stored in the ROM of the controller **1***p*.

There will be next explained, with reference to FIG. **8**, one example of the calculation of the predetermined length of time T and changes in speed (an absolute value of velocity) at which the sheet P is conveyed (hereinafter may be referred to as "sheet conveying speed") in a process in which a direction in which the sheet P is conveyed (hereinafter may be referred to as "sheet conveying direction") is switched from the first direction D1 to the second direction D2 in the duplex recording.

In FIG. **8**, the vertical axis represents the sheet conveying speed at which the roller pair **27** conveys the sheet P, and the horizontal axis represents a time elapsed. The conveying speed is determined by a speed of rotation of the drive roller and the diameter of the drive roller. The conveying speed at which the sheet P is conveyed in the first direction D1 is represented by a positive value, and the conveying speed at which the sheet P is conveyed in the second direction D2 is represented by a negative value. The roller pairs **26**, **27** are rotated such that the sheet P is conveyed at the speed V1 in the first direction D1 and at the speed V2 (which is greater than the speed V1) in the second direction D2. The time point t0 is a point in time when the leading edge of the sheet P reaches the sensing position P2 or when a positive decision (YES) is made at S**12**. The time point t1 is a point in time when the leading edge of the sheet P reaches the drying position P3. The time point t2 is a point in time when an upstream edge portion of the sheet P in the first direction D1 (i.e., a trailing edge of the sheet P conveyed in the first direction D1) reaches the drying position P3. The time point t3 is a point in time when the controller **1**p outputs the command for stopping the driving of the conveyor motor **20**M (at S**14**) or when the conveying speed starts decreasing from the speed V1. The time point t3' is a point in time when the trailing edge of the sheet P reaches a most downstream nipping point P4 in a case where the conveying speed V1 is kept to the time point t3' without the output of the command for stopping the driving of the conveyor motor **20**M at the time point t3. The most downstream nipping point P4 is a position at which the roller pair **27** nips the sheet P. The time point t4 is a point in time when the rotations of the roller pairs **26**, **27** are completely stopped, and the conveying speed becomes zero after the time point t3. The time point t5 is a point in time when the controller **1**p outputs the command for rotating the conveyor motor **20**M in the reverse direction (at S**15**) or when the roller pair **26** starts rotating in the reverse direction, and the conveying speed starts increasing (in the negative direction or the down direction in FIG. **8**). The time point t6 is a point in time when the conveying speed finishes increasing, and the conveying speed becomes constant at the speed V2 after the time point t5. The time point t7 is a point in time when the leading edge of the sheet P conveyed in the second direction D2 (i.e., a downstream edge of the sheet P in the second direction D2) reaches the drying position P3. The time T1 is a length of time extending from the time point t0 to the time point t1, the time T2 is a length of time extending from the time point t1 to the time point t2, the time T3 is a length of time extending from the time point t2 to the time point t3, the time T3' is a length of time extending from the time point t2 to the time point t3', the time T4 is a length of time extending from the time point t3 to the time point t4, and the time T5 is a length of time extending from the time point t5 to the time point t6.

The predetermined length of time T is calculated, for example, by the following Equations (1) and (2):

$$T=T1+T2+T3 \tag{1}$$

$$\alpha \le T3 \le T3'-T4 \tag{2}$$

In a case where a distance L1 by which the sheet P is conveyed during the time T4 is equal to or longer than a distance L2 by which the sheet P is conveyed during the time T5, the value α is zero, and in a case where the distance L1 is shorter than the distance L2, the value α is a length of time in which the sheet P is conveyed at the speed V1 by a distance obtained by subtracting the distance L1 from the distance L2 (L2−L1). In other words, the distance L1 is a distance by which the sheet P is conveyed in a period from the time point t3 at which the conveying speed starts decreasing from the speed V1 to the time point t4 at which the rotations of the roller pairs **26**, **27** are completely stopped, and the conveying speed becomes zero. The distance L2 is a distance by which the sheet P is conveyed in a period from the time point t5 at which the roller pair **26** starts rotating in the reverse direction, and the conveying speed starts increasing (in the negative direction or the down direction in FIG. **8**), to the time point t6 at which the conveying speed becomes constant at the speed V2.

The time T1 is a length of time extending from the time point t0 at which the leading edge of the sheet P reaches the sensing position P2 to the time point t1 at which the leading edge of the sheet P reaches the drying position P3. The time T1 is calculated by dividing the length of the conveyance path from the sensing position P2 to the drying position P3, by the conveying speed V1. The time T2 is a length of time extending from the time point t1 at which the leading edge of the sheet P reaches the drying position P3, to the time point t2 at which the trailing edge of the sheet P reaches the drying position P3. The time T2 is calculated by dividing the length of the sheet P in the conveying direction, by the conveying speed V1. In the present embodiment, this calculation uses the length of the sheet P of the largest size conveyed in the printer **1**. The time T1+T2 is a length of time extending from the time point t0 at which the leading edge of the sheet P reaches the sensing position P2, to the time point t2 at which the trailing edge of the sheet P reaches the drying position P3. The time T3' is a length of time extending from the time point t2 at which the trailing edge of the sheet P reaches the drying position P3 to the time point t3' at which the trailing edge of the sheet P reaches the most downstream nipping point P4 in the case where the command for stopping the driving of the conveyor motor **20**M is not output at the time point t3, and the conveying speed V1 is kept. The time T3' is calculated by dividing the length of the conveyance path from the drying position P3 to the most downstream nipping point P4, by the conveying speed V1. The time T4 is a length of time extending from the point in time when the controller **1**p outputs the command for stopping the driving of the conveyor motor **20**M (at S**14**), i.e., from the time point t3 at which the conveying speed starts decreasing from the speed V1, to the time point t4 at which the rotations of the roller pairs **26**, **27** are completely stopped, and the conveying speed becomes zero after the time point t3. The time T4 may be an acceleration or deceleration time of the conveyor motor **20**M, may be obtained by calculation using acceleration of the roller pairs **26**, **27**, and may be obtained based on an actual measurement value. Each of the distance L1 and the distance L2 may be obtained by calculation using the acceleration of the roller pairs **26**, **27** and may be obtained based on an actual measurement value obtained by a result of image-taking of a high-speed camera, for example. Each of the acceleration and the actual measurement value for the time T4 may be obtained based on the actual measurement value obtained by the result of image-taking of the high-speed camera, for example.

Here, in the case where the distance L1 is equal to or longer than the distance L2, the predetermined length of time T can be expressed by the following Equation (3) based on Equations (1) and (2).

$$T1+T2 \le T \le T1+T2+T3'-T4 \tag{3}$$

The predetermined length of time T is a length of time extending from the point in time when the leading edge of the sheet P conveyed in the first direction D reaches the sensing position P2, to a point in time that is after the trailing edge of the sheet P conveyed in the first direction D reaches the drying position P3 and that is the time T4 (i.e., the length of time extending from the start of decrease of the conveying speed of the roller pairs **26**, **27** to the stop of the roller pairs **26**, **27**) before the time point t3' (at which the trailing edge of the sheet

P reaches the most downstream nipping point P4 where the sheet P is conveyed at the constant velocity V1). The reason why the end of the predetermined length of time T is defined at the point in time that is in advance of the time T4 before the time point t3' is that if the end of the predetermined length of time T is after the trailing edge of the sheet P reaches the most downstream nipping point P4 when the rotations of the roller pairs **26**, **27** are stopped, the sheet P is not nipped by the roller pair **27** when the rotations of the roller pairs **26**, **27** are stopped. In the case where the trailing edge of the sheet P is not nipped by the roller pair **27**, the sheet P has been discharged onto the sheet-output portion **31**, and even if the roller pairs **26**, **27** are rotated in the reverse direction, the sheet P is not conveyed in the second direction D2. Since the above-described predetermined length of time T is set in the present embodiment, however, the conveying speed decreases after the trailing edge of the sheet P passes through the drying position P3, eliminating unevenness in drying the sheet P conveyed in the first direction D1. Also, the conveying speed is constant at the speed V2 before the leading edge of the sheet P in the second direction D2 reaches the drying position P3, eliminating unevenness in drying the sheet P conveyed in the second direction D2.

In the case where the distance L1 is shorter than the distance L2, the predetermined length of time T can be expressed by the following Equation (4) based on Equations (1) and (2).

$$T1+T2+\alpha \leq T \leq T1+T2+T3'-T4 \quad (4)$$

The predetermined length of time T is a length of time extending from the point in time when the leading edge of the sheet P reaches the sensing position P2, to a point in time that is after a lapse of time α starting from the timing when the trailing edge of the sheet P reaches the drying position P3 and that is the time T4 (i.e., the length of time extending from the start of decrease of the conveying speed of the roller pairs **26**, **27** to the stop of the roller pairs **26**, **27**) before the time point t3' (at which the trailing edge of the sheet P reaches the most downstream nipping point P4 where the sheet P is conveyed at the constant velocity V1). In this setting of the predetermined length of time T, the conveying speed decreases after a lapse of time α starting from the timing when the trailing edge of the sheet P passes through the drying position P3, eliminating unevenness in drying the sheet P conveyed in the first direction D1. Also, the conveying speed is constant at the speed V2 before the trailing edge of the sheet P reaches the drying position P3, eliminating unevenness in drying the sheet P conveyed in the second direction D2. That is, in the case where the distance L1 is shorter than the distance L2, if the predetermined length of time T is set at the time T1+T2, the conveying speed becomes constant at the speed V2 after the point in time when the leading edge of the sheet P conveyed in the second direction D2 reaches the drying position P3 with the roller pairs **26**, **27** being rotated in the reverse direction, leading to unevenness in drying (i.e., a degree of drying) the sheet P conveyed in the second direction D2. Thus, in the case where the distance L1 is shorter than the distance L2, the predetermined length of time T is set based on Equation (4) in the present embodiment, eliminating unevenness in drying both the sheet P conveyed in the first direction D1 and the sheet P conveyed in the second direction D2.

Since the predetermined length of time T is set as described above, when the conveying direction is switched from the first direction D1 to the second direction D2 in the duplex recording, the sheet P is temporarily stopped when the trailing edge of the sheet P conveyed in the first direction D1 is located between the drying position P3 and the most downstream nipping point P4 (i.e., on a downstream side of the drying position P3 in the first direction D1 and an upstream side of the most downstream nipping point P4 in the first direction D1), and the sheet P is thereafter conveyed in the second direction D2.

In the present embodiment, the processing at S**11** is one example of a first processing, the processings at S**12**-S**14** are one example of a second processing, the processing at S**15** is one example of a third processing, and the processing at S**16** is one example of the fourth processing.

In the present embodiment as described above, the sheet P is dried and conveyed until the trailing edge of the sheet P conveyed in the first direction D1 reaches a position located downstream of the drying position P3 in the first direction D1 in the second processing (S**12**-S**14**), and the sheet P is thereafter conveyed in the second direction D2 in the third processing (S**15**). As a result, the entire sheet P can be dried without unevenness. That is, it is possible to reduce an amount of unevenness in a degree of drying of the sheet P.

In the second processing (S**12**-S**14**), as illustrated in FIG. **8**, the controller **1***p* controls the second conveyor **20***b* such that the sheet conveying speed starts decreasing after at least an upstream edge portion of an image-recorded area on the front surface of the sheet P in the first direction D1 (in the present embodiment, the trailing edge of the sheet P) passes through the drying position P3. If the sheet conveying speed starts decreasing before the trailing edge of the image-recorded area passes through the drying position P3 in the second processing, unevenness occurs in the degree of dryness in the image-recorded area, leading to a low image quality. However, the above-described configuration can reduce an amount of lowering of the image quality.

In addition, the trailing edge of the sheet P conveyed in the first direction D1 is used as a reference in the above-described control in the present embodiment. Accordingly, the above-described effects can be obtained with simple control when compared with a case where the trailing edge of the image-recorded area is used as a reference.

In the third processing (S**15**), as illustrated in FIG. **8**, the controller **1***p* controls the second conveyor **20***b* such that the increase in the sheet conveying speed is finished, and the sheet conveying speed becomes constant before at least the downstream edge portion of the image-recorded area on the front surface of the sheet P in the second direction D2 (in the present embodiment, the leading edge of the sheet P conveyed in the second direction D2) passes through the drying position P3. In the third processing, if the sheet conveying speed is not constant but continues increasing when the leading edge of the image-recorded area passes through the drying position P3, unevenness occurs in the degree of dryness in the image-recorded area, leading to a low image quality. However, the above-described configuration can reduce an amount of lowering of the image quality.

In addition, the leading edge of the sheet P conveyed in the second direction D2 is used as a reference in the above-described control in the present embodiment. Accordingly, the above-described effects can be obtained with simple control when compared with the case where the leading edge of the image-recorded area is used as a reference.

Based on the signals output by the sensor **32**, the controller **1***p* controls the second conveyor **20***b* to change the sheet conveying speed. Accordingly, the above-described effects can be obtained with simple control.

The controller **1***p* controls the heater **26***ah* to dry the sheet P in both of the second processing (S**12**-S**14**) and the third processing (S**15**). Insufficient dying of the sheet P causes the ink to stick to components constituting the third conveyor **20***c* and the first conveyor **20***a* in the fourth processing (S**16**). In the present embodiment as described above, the sheet P is dried in both of the second processing and the third processing, increasing the degree of dryness of the sheet P to address this problem.

It is possible to consider that electric power for driving the heater **26***ah* is increased in the second processing to sufficiently dry the sheet P in a configuration in which the sheet P is dried only in the second processing. It is assumed in this configuration that the sheet P is dried with the same drive power also in the second processing in the simplex recording (i.e., before the sheet P is discharged to the outside of the housing **1***a*). However, there is a low possibility that the sheet P is nipped firmly by, e.g., components constituting the conveyor after the sheet P is discharged to the outside of the housing **1***a*. On the other hand, the sheet P conveyed by the third conveyor **20***c* is nipped by the roller pairs constituting the third conveyor **20***c* and the roller pairs constituting the first conveyor **20***a*. Thus, insufficient drying of the sheet P causes the ink to stick to the roller pairs constituting the third conveyor **20***c* and the first conveyor **20***a* in particular. If the ink has sticked to the roller pairs constituting the third conveyor **20***c* and the first conveyor **20***a*, the ink may stick to a sheet P conveyed next. Accordingly, in the second processing in the simplex recording, the degree of dryness of the sheet P can be set low when compared with a period before image recording is performed on the back surface of the sheet P in the duplex recording (i.e., before the fourth processing). That is, the degree of dryness of the sheet P to be discharged to the outside of the housing **1***a* may be set at a low value when compared with the sheet P conveyed by the third conveyor **20***c*. If the heater **26***ah* is driven by great drive power in the second processing in the simplex recording in spite of this circumstance, consumption of electric power becomes larger than necessary, resulting in higher cost. In the configuration in which the sheet P is dried in both of the second processing and the third processing, the degree of dryness of the sheet P conveyed by the third conveyor **20***c* can be increased with lower consumption of electric power.

Also, the first conveyor **20***a* is configured to convey the sheet P to the recording position. The second conveyor **20***b* is configured to convey the image-recorded sheet P to the sheet-output portion **31** or the third conveyor **20***c*, and the third conveyor **20***c* is configured to convey the image-recorded sheet P to the first conveyor **20***a*. Thus, the first conveyor **20***a* needs high conveying accuracy when compared with the second conveyor **20***b* and the third conveyor **20***c*. In other words, the first conveyor **20***a* needs a high conveying force when compared with the second conveyor **20***b* and the third conveyor **20***c*. Accordingly, the nip pressure of each roller pair of the first conveyor **20***a* is preferably higher than that of each roller pair of the second conveyor **20***b* and the third conveyor **20***c*. Alternatively, the area of contact between the rollers of each roller pair of the first conveyor **20***a* is preferably larger than that between the rollers of each roller pair of the second conveyor **20***b* and the third conveyor **20***c*. For example, one of the rollers of each roller pair of the second conveyor **20***b* and the third conveyor **20***c*, which one is to contact the first surface of the recording medium, may be constituted by a spur for reducing the area of contact with the sheet P. In this configuration, drying the sheet P in both of the second processing (S**12**-S**14**) and the third processing (S**15**) can reduce an amount of ink transferring to the roller pairs of the first conveyor **20***a* when the image-recorded sheet P is conveyed. On the other hand, each roller pair of the second conveyor **20***b* and the third conveyor **20***c* has a reduced conveying force, preventing the transfer of the ink.

The controller **1***p* controls the roller pairs **26**, **27** in the second processing (S**12**-S**14**) and the third processing (S**15**) such that the rotational speeds of the respective roller pairs **26**, **27** are different from each other (see V1 and V2 in FIG. **8**), so that the sheet conveying speed is different from each other between the second processing and the third processing. As a result of this control, an amount of heat supplied to the sheet P by the dryer **50** is different between the second processing and the third processing. Therefore, the degree of dryness of the sheet P can be adjusted appropriately for each of the simplex recording and the duplex recording.

In addition, the controller **1***p* controls not the dryer **50** but the second conveyor **20***b* to generate different amounts of heat in the present embodiment. In this configuration, the above-described effects can be more reliably obtained with simpler control than in a configuration in which the controller **1***p* controls the dryer **50** to generate different amounts of heat.

In the present embodiment, the speed V2 is greater than the speed V1, and the sheet conveying speed is higher in the third processing than in the second processing. This configuration allows high-speed recording.

The dryer **50** includes: the forward/reverse rotatable roller pair **26** partly constituting the second conveyor **20***b* and rotatable forwardly and reversely; and the heater **26***ah* for heating one of the two rollers **26***a*, **26***b* constituting the roller pair **26**, in the present embodiment, the roller **26***a*, resulting in simple configuration when compared with a configuration in which a heater is provided additionally.

The second conveyor **20***b* includes the forward/reverse rotatable roller pair **27** rotatable forwardly and reversely and disposed downstream of the drying position P3 in the first direction D1. This configuration enables stable conveyance of the sheet P in the second direction D2.

The dryer **50** includes the roller **26***a* that is the contact member for applying heat to the sheet P in the state in which the roller **26***a* contacts at least the front surface of the sheet P. The front surface of the sheet P needs to be dried in particular because the ink may stick to the components of the third conveyor **20***c* and the fast conveyor **20***a* in the fourth processing (S**16**) due to contact of the front surface of the sheet P with the components of the third conveyor **20***c* and the first conveyor **20***a*. In the above-described configuration, the front surface can be dried sufficiently, reliably preventing the ink from sticking to the components of the third conveyor **20***c* and the first conveyor **20***a*.

To prevent the ink from sticking to the back surface of the sheet P, spur rollers or other similar components can be used as components which constitute the third conveyor **20***c* and the first conveyor **20***a* and contact the back surface. Accordingly, problems are less caused on the back surface of the sheet P due to insufficient drying when compared with the front surface of the sheet P.

There will be next explained an ink-jet printer **101** according to a second embodiment of the present invention with reference to FIG. **9**.

The printer **101** is similar in construction to the printer **1** according to the first embodiment except for a conveyor unit. It is noted that the same reference tags as used in the first embodiment are used to designate the corresponding elements of the second embodiment, and an explanation of which is dispensed with.

In this embodiment, a conveyor unit **120** includes the first conveyor **20***a*, the second conveyor **20***b*, and a third conveyor **120***c*. The third conveyor **120***c* conveys the sheet P conveyed in the second direction D2 by the second conveyor **20***b*, along hatched arrows D3 in FIG. **9** to a position located upstream of the recording position P1 in the first direction D1 (i.e., the position near the roller pair **24** on an upstream side thereof), so as to return the sheet P into the sheet conveyance path of the first conveyor **20***a*. The third conveyor **120***c* includes the roller pairs **23**, **24** of the first conveyor **20**; the roller pair **25** of the second conveyor **20***b*, roller pairs **128**, **129**, and guides **129***f*-**129***h*.

In the present embodiment, not only the roller pairs **26**, **27** but also the roller pairs **23**-**25** are forward/reverse rotatable roller pairs rotatable forwardly and reversely. When the command for rotating the conveyor motor **20**M in the reverse direction is output at S**15**, the roller pairs **23**-**27** are rotated in the reverse direction. As a result, the sheet P is conveyed by the second conveyor **20***b* in the second direction D2 into the third conveyor **20***c* in which the sheet P is conveyed along the arrow D3 while being nipped by the roller pairs **25**, **24**, **23**, **128**, **129** in order and returned into the conveyance path of the first conveyor **20***a*.

The printer **101** according to the second embodiment differs from the printer **1** according to the first embodiment in the conveyance path but can obtain the same effects as obtained in the printer **1** due to its configuration similar to that of the printer **1**.

There will be next explained an ink-jet printer according to a third embodiment of the present invention.

As illustrated in FIG. **10**, the printer according to the present embodiment differs from the printer **1** according to the first embodiment only in that the sheet conveying speed in the second processing (S**12**-S**14**) is set at the speed V2, and the sheet conveying speed in the third processing (S**15**) is set at the speed V1 that is lower than the speed V2. That is, in the present embodiment, the controller **1***p* controls the second conveyor **20***b* such that the sheet conveying speed is less in the third processing than in the second processing.

The printer according to the third embodiment differs from the printer **1** according to the first embodiment in the control of the rotational speed of the roller pairs **26**, **27** but can obtain the same effects as obtained in the printer **1** due to its configuration similar to that of the printer **1**.

While the embodiments of the present invention have been described above, it is to be understood that the invention is not limited to the details of the illustrated embodiments, but may be embodied with various changes and modifications, which may occur to those skilled in the art, without departing from the spirit and scope of the invention.

The roller of the dryer may be any of a drive roller and a driven roller. The dryer may have any configuration as long as the dryer can reduce an amount of water contained in the recording medium. For example, the dryer may be constituted by a component specific to drying instead of the roller constituting the conveyor. In this configuration, the component is heated, and the recording medium is brought into contact with the heated component and dried due to heat conduction. A porous member such as a felt and a sponge may be used as the dryer. This porous member is disposed so as to contact the recording medium and absorb water therefrom to dry the recording medium. As one example of this configuration, an absorber including a rigid roller and a felt covering an outer surface of the roller may be provided such that the recording medium is brought into contact with an outer circumferential surface of the absorber which is formed of the felt. In this configuration, a suction mechanism may be provided for the roller to suck absorbed water as needed.

The dryer may dry the recording medium using convection and/or radiation without contacting the recording medium. In the case of convection, the temperature of air is not limited, and any of cool air and warm air may be used. Also, the dryer may be configured to dry the recording medium using high-temperature air without generating the convection. In a case of using a recording medium containing water which contains infrared absorbent, the dryer may be configured to dry the recording medium by applying infrared light to the recording medium. The dryer may be configured to dry the recording medium by applying electromagnetic waves to the recording medium to generate heat therein utilizing molecular motion. The dryer may be configured to dry the recording medium by applying ultrasonic waves to the recording medium to repeat depressurization and pressurization. The dryer may be configured to dry the recording medium by sucking water contained in the recording medium by means of a suction mechanism.

The dryer may further include a nip-pressure changing mechanism **60** for changing a nip pressure of the roller pair **26** partly constituting the dryer. Specifically, as illustrated in FIG. **11**, the nip-pressure changing mechanism **60** includes a roller holder **61**, an arm **62**, a spring **63**, and an eccentric cam **64**. The roller holder **61** supports a rotation shaft of the roller **26***b* rotatably. The arm **62** has a T-shape when viewed in the horizontal direction and is mounted on an upper face of the roller holder **61**. The arm **62** is fitted in a through hole formed in the frame **65** held by the housing **1***a*. The spring **63** urges the roller holder **61** and the frame **65** such that the roller holder **61** and the frame **65** are moved away from each other. The eccentric cam **64** is rotated with its rotation shaft receiving a drive force of a motor. The eccentric cam **64** is rotated in a state in which its outer circumferential surface is held in contact with an upper end portion of the arm **62**. The rotation of the eccentric cam **64** changes a nip pressure of the roller **26***a* and the roller **26***b*, the configuration in which the dryer includes the nip-pressure changing mechanism **60**, the controller **1***p* may control the nip-pressure changing mechanism **60** such that the nip pressure of the roller pair **26** is different between the second processing and the third processing. More preferably, the controller **1***p* may control the nip-pressure changing mechanism **60** such that the nip pressure of the roller pair **26** is greater in the third processing than in the second processing. In this control, the nip pressure of the roller pair **26** is relatively small in the second processing, preventing the ink from transferring to the roller pair **26** when the image-recorded surface of the sheet P contacts the roller pair **26**. In the third processing, on the other hand, the nip pressure of the roller pair **26** is relatively large, improving efficiency of drying the image-recorded surface when the image-recorded surface of the sheet P contacts the roller pair **26**. Here, since the image-recorded surface of the sheet P had been heated in the second processing, the image-recorded surface has been dried in some degree at the start of the third processing, making it difficult for the ink to be transferred to the roller pair **26** in the third processing even when the image-recorded surface of the sheet P contacts the roller pair **26**. It is noted that in the case of the simplex recording, the controller **1***p* controls the nip-pressure changing mechanism **60** such that the nip pressure of the roller pair **26** is equal to that of the roller pair **26** in the second processing.

The medium conveying path formed by the conveyor is not limited to that in the above-described embodiments and may be changed as needed. A plurality of roller pairs of the conveyor may be rotated at the same speed or different speeds. For example, conveyor motors may be connected respectively to drive rollers of the roller pairs, and rotations of the conveyor motors may be controlled individually. The conveying speed in the first direction and the conveying speed in the second direction may be different from or equal to each other. Any configuration may be employed for a conveyor motor and a drive-power transmitting mechanism.

The controller may control the dryer or both of the dryer and the second conveyor such that an amount of heat applied to the recording medium by the dryer is different between the second processing and the third processing. The controller may control the dryer not to dry the recording medium in the third processing but to dry the recording medium only in the second processing. Specifically, the heater **26***ah* may be turned off between S**14** and S**15**. The controller may control the second conveyor in the second processing such that the conveying speed of the recording medium starts decreasing not after the trailing edge of the recording medium passes through the drying position but after the trailing edge of the image-recorded area on the front surface of the recording medium passes through the drying position. Specifically, the predetermined length of time T may be set, taking margins of the recording medium into consideration. For example, in the case where the distance L1 is equal to or longer than the distance L2, the predetermined length of time T may be set according to the following equation: $T1+T2-\beta \le T \le T1+T2+T3'-T4$. The value β is a length of time required for conveyance of a downstream margin of the recording medium in the first direction at the conveying speed V1 and can be obtained by dividing the length of the margin in the first direction by the conveying speed VI. In the case where the distance L1 is shorter than the distance L2, on the other hand, the predetermined length of time T may be set according to the following equation: $T1+T2+\alpha-\beta \le T \le T1+T2+T3'-T4$.

The controller may control the second conveyor in the third processing such that the increase in the conveying speed of the recording medium is completed, and the conveying speed becomes constant not before the leading edge of the recording medium conveyed in the second direction D2 passes through the drying position but before the leading edge of the image-recorded area on the front surface of the recording medium passes through the drying position. The controller may control the position of the recording medium and execute the control for conveyance not based on the signals output from the sensors but based on the number of rotations of the conveyor motor.

The predetermined length of time T may be calculated by actual measurements for each size of the recording medium, and the controller may store a table representative of the predetermined length of time T for each size of the recording medium, into the ROM. The controller may obtain the predetermined length of time T in other suitable methods.

While the point in time when the leading edge of the recording medium conveyed in the first direction D1 reaches the sensing position is set as the start of the predetermined length of time T in the above-described embodiments, the point in time when the trailing edge of the recording medium conveyed in the first direction D1 reaches the sensing position may be set as the start of the predetermined length of time T. The sensor may be disposed at any position that is located upstream of the drying position in the first direction. While the controller selectively executes one of the simplex recording control and the duplex recording control based on the recording command in the above-described embodiment, the controller may be configured to execute only the duplex recording control without executing the control for the simplex recording.

The liquid ejection head may be a serial head instead of the line head. The liquid ejected from the liquid ejection head is not limited to the ink and may be any liquid such as pretreatment liquid. The actuator for applying energy for ejecting liquid from the ejection openings is not limited to the piezoelectric actuator using piezoelectric elements and may be other types of actuators such as a thermal actuator using heating elements and an electrostatic actuator using an electrostatic force. The liquid ejection apparatus may include any number of liquid ejection heads as long as at least one liquid ejection head is provided. The recording medium is not limited to the sheet P and may be any recordable medium. The liquid ejection apparatus according to the present invention is not limited to the printer and may be other similar devices such as a facsimile machine and a copying machine.

What is claimed is:

1. A liquid ejection apparatus, comprising:

a liquid ejection head formed with a plurality of ejection openings and configured to eject liquid from the plurality of ejection openings;

a first conveyor configured to convey a recording medium in a first direction to a recording position which opposes the plurality of ejection openings;

a second conveyor disposed downstream of the recording position in the first direction, the second conveyor being configured to convey the recording medium conveyed by the first conveyor, in the first direction and a second direction that is reverse to the first direction;

a third conveyor configured to convey the recording medium conveyed in the second direction by the second conveyor, to an upstream side of the recording position in the first direction to enter the recording medium into a conveyance path of the first conveyor;

a dryer configured to dry the recording medium conveyed by the second conveyor, at a drying position located downstream of the recording position in the first direction; and

a controller configured to control the liquid ejection head, the first conveyor, the second conveyor, the third conveyor, and the dryer,

the controller being configured to execute:

a first processing in which the controller controls the liquid ejection head and the first conveyor to record an image on a first surface of the recording medium which opposes a second surface thereof;

a second processing in which after the first processing the controller controls the second conveyor to convey the recording medium for which the image is recorded on the first surface thereof; in the first direction until an upstream edge portion of the recording medium in the first direction reaches a position located downstream of the drying position in the first direction;

a third processing in which after the second processing the controller controls the second conveyor to convey the recording medium for which the image is recorded on the first surface thereof; in the second direction; and

a fourth processing in which after the third processing the controller controls the third conveyor, the first conveyor, and the liquid ejection head to record an image on the second surface of the recording medium,

the controller being configured to control the dryer to dry the recording medium at least in the second processing.

2. The liquid ejection apparatus according to claim **1**, wherein the controller controls the dryer to dry the recording medium in both of the second processing and the third processing.

3. The liquid ejection apparatus according to claim **1**, wherein the dryer comprises: a first forward/reverse rotatable roller pair at least partly constituting the second conveyor and rotatable forwardly and reversely; and a heater configured to heat at least one of two rollers constituting the first forward/reverse rotatable roller pair.

4. The liquid ejection apparatus according to claim 1, wherein the controller is configured to control the dryer such that a nip pressure of the first forward/reverse rotatable roller pair in the second processing is different from that in the third processing.

5. The liquid ejection apparatus according to claim 1, wherein the second conveyor comprises a second forward/reverse rotatable roller pair rotatable forwardly and reversely and disposed downstream of the drying position in the first direction.

6. The liquid ejection apparatus according to claim 1, wherein the dryer comprises a contact member configured to contact at least the first surface of the recording medium to apply heat to the recording medium.

7. The liquid ejection apparatus according to claim 1, wherein the controller is configured to control the second conveyor in the second processing such that a conveying speed of the recording medium starts decreasing after at least an upstream edge portion of an image-recorded area on the first surface on which the image is recorded in the first direction passes through the drying position.

8. The liquid ejection apparatus according to claim 7, wherein the controller is configured to control the second conveyor in the second processing such that the conveying speed of the recording medium starts decreasing after the upstream edge portion of the recording medium in the first direction passes through the drying position.

9. The liquid ejection apparatus according to claim 7, further comprising a sensor disposed upstream of the drying position in the first direction and configured to output a signal responsive to a position of the recording medium conveyed along a conveyance path,

wherein the controller is configured to control the second conveyor to change the conveying speed based on the signal output by the sensor.

10. The liquid ejection apparatus according to claim 1, wherein the controller is configured to control the second conveyor in the third processing such that a conveying speed of the recording medium finishes increasing and becomes constant before at least an upstream edge portion of an image-recorded area on the first surface on which the image is recorded in the first direction passes through the drying position.

11. The liquid ejection apparatus according to claim 10, wherein the controller is configured to control the second conveyor in the third processing such that the conveying speed of the recording medium finishes increasing and becomes constant before the upstream edge portion of the recording medium in the first direction passes through the drying position.

12. The liquid ejection apparatus according to claim 1,

wherein the dryer is configured to apply heat to the recording medium, and

wherein the controller is configured to control at least one of the second conveyor and the dryer such that an amount of heat applied to the recording medium by the dryer in the second processing is different from that in the third processing.

13. The liquid ejection apparatus according to claim 12, wherein the controller is configured to control the second conveyor such that a conveying speed of the recording medium in the second processing is different from that in the third processing.

14. The liquid ejection apparatus according to claim 13, wherein the controller is configured to control the second conveyor such that the conveying speed of the recording medium is greater in the third processing than in the second processing.

15. The liquid ejection apparatus according to claim 13, wherein the controller is configured to control the second conveyor such that the conveying speed of the recording medium is less in the third processing than in the second processing.

16. A liquid ejection apparatus, comprising:

a liquid ejection head formed with a plurality of ejection openings and configured to eject liquid from the plurality of ejection openings;

a first conveyor configured to convey a recording medium in a first direction to a recording position which opposes the plurality of ejection openings;

a second conveyor disposed downstream of the recording position in the first direction, the second conveyor being configured to convey the recording medium conveyed by the first conveyor, in the first direction and a second direction that is reverse to the first direction;

a third conveyor configured to convey the recording medium conveyed in the second direction by the second conveyor, to an upstream side of the recording position in the first direction to enter the recording medium into a conveyance path of the first conveyor; and

a dryer configured to dry the recording medium conveyed by the second conveyor, at a drying position located downstream of the recording position in the first direction,

the dryer comprising: a first forward/reverse rotatable roller pair at least partly constituting the second conveyor and rotatable forwardly and reversely; and a heater configured to heat at least one of two rollers constituting the first forward/reverse rotatable roller pair,

the second conveyor comprising a second forward/reverse rotatable roller pair rotatable forwardly and reversely, the second forward/reverse rotatable roller pair being disposed downstream of the drying position in the first direction.

* * * * *